SAFETY REQUIREMENTS FOR

MAN-RATING SPACE SYSTEMS

DRAFT

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FOREWORD

This document presents a consolidated set of safety requirements for man-rating space systems which are to be employed in future Manned Space Flight programs. Man-rating is the activity of assuring that all requirements, necessary for certifying systems as suitable for man's use, have been satisfied.

The safety requirements presented herein are applicable to all project phases of a system's life cycle and encompass flight, ground, and experimental systems.

Documentation from the Mercury, Gemini, and Apollo Programs were studied in the determination of these safety requirements, as was applicable data from other government agencies such as the Department of Defense and the Department of Transportation. Discussions were also held with individuals having specialized experience in determining these requirements.

Additions and revisions to these safety requirements will be made as experience gained from on-going programs, and state-of-the-art advances, dictate. Recommendations for changes, additions, or deletions are invited.

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SECTION I—INTRODUCTION

SECTION I—INTRODUCTION

1.0 PURPOSE

The purpose of this document is to establish uniform, coordinated safety requirements for man-rating of NASA space Systems. These requirements also provide a baseline for assessing the safety adequacy of systems and equipments intended for man's use.

2.0 AUTHORITY

The authority for this document is derived from:

a. NMI 1138.12 Functions and Authority, Director, Manned Space Flight Safety.

b. NHB 1700.1 NASA Safety Manual (draft in final coordination).

c. NMI 1700._ Manned Space Flight Safety Program (draft in final coordination).

3.0 SCOPE

The safety requirements contained in this document cover all NASA space systems including flight, ground, and experimental equipment through all project phases of a system's life-cycle. Safety requirements for the man-rating facilities (both test and launch) are also included. This document further establishes the requirements for the applying man-rating considerations to key management check points and technical reviews to assure satisfaction of the man-rating objective, and to make recommendation for corrective action on open safety items.

4.0 APPLICABILITY AND DEVIATIONS

4.1 APPLICABILITY

The safety requirements contained herein are applicable to all phases of new manned programs.

4.2 DEVIATIONS

Requests for deviations from the requirements of this document must be submitted to the Director, Manned Space Flight Safety, Code MY. The request should include:

a. Identification and extent of the deviation.

b. Degree of urgency for approval of the request.

c. Justification for the deviation specifying:

   (1) Specific limitation(s) or obstacle(s) which prevent fulfillment of the requirement.

   (2) Program impact if the deviation is not approved.

   (3) Recommended alternate action.

Copies of deviation requests should be distributed to all program groups which might be effected by the deviation, and a list of these recipients should be forwarded to the Director, Manned Space Flight Safety.

Recommendations concerning the request for deviation should be forwarded to the Manned Space Flight Safety Office by distribution recipients. A decision will be forwarded to the requestor within 30 days of receipt unless a shorter action time has been agreed to.

5.0 BACKGROUND

Man-rating can be defined as the method which assures that manned space systems have met the requirements established for safety and man-machine relationships so that the system/hardware can be officially certified as suitable for man's use.

With the advent of manned space flights, man-rating has evolved as a specific function of project development. Although the relationship of man to machine has long been a consideration in the development of aerospace systems as a part of engineering/development, its specific consideration relative to personnel safety became critical in the Mercury and Gemini programs. The experience derived from these two early programs, coupled with the increased hazards anticipated from the hostile environment of outer space, requires that man-rating be implemented on a planned, organized basis as an integral element of the Manned Space Flight Safety Program.

Implementation of man-rating is accomplished by applying a combined process of specifically identified engineering techniques and close management control throughout the life cycle of a program. The process consists of the following major elements:

a. Establishment of safety requirements for each phase of program/project development and operation.

b. Implementing these safety requirements into design, reliability, quality control, test, manufacturing, operation, and maintenance.

c. Monitoring the man-rating process at all key management checkpoints.

d. Identification of a man-rating authority to make trade-off, scheduling, and cost decisions.

e. Application of a Personnel Program which (1) assures timely availability of qualified and certified personnel, and (2) creates and maintains an awareness of the importance of safety.

The safety requirements established in this document represent the first step in the man-rating process (a, above). They provide the man-rating requirements baseline against which the remainder of the process can be accomplished from the safety viewpoint.

Many of the safety requirements contained herein are the inherent responsibility of other technical disciplines. However, the safety impact of these requirements necessitates their collateral delineation as safety requirements. The satisfaction of these requirements will continue to be accomplished by the cognizant discipline within line management. The safety activity will monitor this accomplishment to assure that the overall interest of safety are satisfied.

6.0 APPROACH

The basic approach used in developing/selecting these requirements was to (1) utilize all existing man-rating intelligence applicable to OMSF programs either directly or with modifications, and (2) establish new requirements for areas unique to OMSF which were not part of past programs.

Preparation of the safety requirements was broken down into the following elements of work:

a. Review and evaluation of existing and past man-rating programs for adaption to OMSF. (Documentation reviewed included issuances from NASA Headquarters, NASA Centers, USAF, U.S. Navy, contractors, and the Department of Transportation. Subject matter covered Mercury, Gemini, Saturn IB and V, altitude chambers, spacecrafts, space suits, medical and biological considerations, flight and operational readiness, fire under high pressure, space simulators, and human standards.)

b. Utilization of results of studies conducted by agencies recognized as authoritative in the field.

c. Selection of requirements currently applied on Apollo and AAP which, although not so identified, were directly applicable to man-rating.

d. Contact with individuals, both NASA and other agencies, who have had functional or management concern for man-rating or safety on other programs, and the utilization of their experience and opinions.

e. Identification of areas unique to OMSF programs and which, consequently, have had little or no man-rating emphasis on other programs.

Utilizing the above approach, the man-rating requirements contained in this collection have been substantiated by historical intelligence, qualified direct experience, authoritative study conclusions, and analysis of current OMSF programs.

The requirements were evaluated by designated NASA and qualified contractor personnel and no requirement was included until an understanding of the intent of the requirement and general agreement as to its applicability was reached. The governing considerations against which each requirement was measured for inclusion were (1) technological and/or management value in fulfillment of NASA safety requirements, and (2) practicality relative to time (scheduling) and cost.

7.0 ORGANIZATION

The requirements in this document are organized in functional groups, (design, reliability, test, etc.). By this arrangement, all safety requirements for man-rating, applicable to a functional group, are in one location. Each requirement has been keyed in accordance with the official phasing of NASA projects as established in NHB 7121.2, Phased Project Planning Guideline. NHB 7121.2 identifies four phases of project development: Preliminary Analysis, Definition, Design, and Development/Operation and reflects the management and engineering functions required to implement each phase. The man-rating requirements in this document are keyed to project development phases by the following code letters:

A — Preliminary Analysis

B — Definition

C — Design

D — Development/Operations

These code letters appear in the Phase Applicability box on each requirement.

8.0 REQUIREMENTS UPDATING

This document is open-ended in that it will be continually updated to (1) establish new requirements as the need becomes apparent, and to (2) incorporate changes as indicated by data from on-going space program experience and state-of-the-art advances. Recommendations for changes, additions, and deletions are invited. All such recommendations should be sumbitted to the Manned Space Flight Safety Office, Code MY.

SECTION II—REQUIREMENTS

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
SAFETY PROGRAMS		1.1	1 of 1

Statement of Requirement

Applicable Phase
A, B, C, D

A safety program shall be developed for each individual Manned Space Flight program. The responsible Program Director shall issue a Safety Plan for the program which shall be implemented by all involved NASA agencies and contractors. The Program Safety Plan will serve as the implementing extension of the OMSF safety requirements (as contained herein) for a given MSF program.

Background-Rationale

Safety, as any other discipline, must be planned and managed in order to be implemented systematically. For any given program, safety requirements must be identified and defined, logically programmed and scheduled, and assessed.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date	
IDENTIFICATION OF MISSION HAZARDS		No. 1.2	Page No. 1 of 1

Statement of Requirement

Applicable Phase
A, B, C, D

Each mission shall be analyzed and evaluated to identify all potential hazards. Each hazard shall be classified as operational or environmental. Operational hazards are those hazards connected or integral with the particular vehicle, test apparatus, or ground support installation and the procedures used in operating this equipment. Action shall be taken to eliminate or control these operational hazards, and for those which cannot be eliminated, protective measures and procedures shall be developed and incorporated in the appropriate training programs. Environmental hazards are those hazards external or not connected with the particular apparatus being used (i.e., space radiation, wind, meteoroids, low magnetic field strength (free space), etc.). Action shall be taken to control these environmental hazards, and where the hazards cannot be controlled, protective measures shall be taken to limit the effects of these environmental hazards.

Background-Rationale

Unknown or uninvestigated hazards involved with a particular mission can mean loss of crew, loss of mission, or both. Hazard identification is required in order to provide protective measures and safe procedures for the elimination or control of hazards.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date
DEVELOPMENT OF PROCEDURE STANDARDS AND DESIGN CRITERIA	No. 1.3 — Page No. 1 of 1

Statement of Requirement

Applicable Phase: B, C, D

All NASA installations shall develop, document, and distribute design/safety criteria and procedure standards which shall apply to all (in-house, contractor) equipment being developed or operated under the direction of the particular installation and shall be referenced between NASA installations.

Background-Rationale

These criteria are to be developed as part of a continuing effort to develop safer and more reliable equipment for man use. Design standards cover principles, philosophy, or criteria governing the requirements of the equipment or the conditions to which the equipment shall be designed. They also give detailed requirements to which a particular system, subsystem, or item shall be designed. Procedure standards cover techniques and procedures of manufacture, assembly, servicing, checkout, test and other operations associated with manned equipment. These criteria will also insure conformity among all contractors for a particular installation.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
IDENTIFICATION OF EXPERIMENTAL HAZARDS		1.4	1 of 1

Statement of Requirement

Applicable Phase: A, B, C, D

System Safety personnel shall identify and analyze hazards associated with experiments conducted by NASA installations and their contractors. These analysis shall contribute to overall mission hazard identification.

Background-Rationale

Experiments by their very nature present a potentially hazardous situation since they are concerned with what is essentially unknown. These hazards which are associated with nearly all experiments are more difficult to control and therefore are a greater risk during flight.

Approval

Title	Effective Date	No.	Page No.
HUMAN ENGINEERING APPLIED TO TEST PROCEDURES		1.5	1 of 1

Statement of Requirement

Applicable Phase: C, D

Test procedures shall be subjected to human engineering analysis to identify and modify human actions which contribute to discrepancies in test, to identify potential hazards resulting from human error and to establish the probability of these human actions and test discrepancies occurring in operation of the equipment.

Background-Rationale

Since a great number of tests involve equipment or conditions that are potentially hazardous to the personnel involved with the test, extra care must be taken to insure that the personnel themselves do not set up the hazardous condition by their own actions. It is equally important to insure that the personnel do not invalidate the test results as a result of their actions. Any set of procedures that would make this relatively easy to do, must be modified in such a way so as to either make the personnel aware of what the results would be if they don't follow correct procedures, or change the procedures themselves.

Approval

Title	Effective Date	No.	Page No.
FINAL CERTIFICATION OF MANNED FLIGHT SAFETY		1.6	1 of 1

Statement of Requirement

Applicable Phase: D

Every flight shall receive a final certification of manned flight safety prior to launch. This certification shall be based on a final safety evaluation which shall incorporate the results of all previous safety reviews. This final safety evaluation shall cover the mission, hardware, software, support and operations (including flight crew) in a manner which will facilitate an examination of performance capability (including alternate operating mode capability), maintenance and spares readiness, interface compatibility, and development maturity against specific mission requirements and flight environment.

The review of flight crew operations shall establish the relation between mission requirements, crew tasks, training and simulation operations. The interface between the spacecraft and the astronauts shall be reviewed and related to crew functions. Emphasis shall be placed on potential hazards (including experiment and experimental operations hazards), emergency procedures and unresolved problem areas.

All discrepancies and open items identified in this final evaluation shall be documented and submitted in a report to the Program Director. All such items shall be corrected/closed prior to the final certification of manned flight safety.

Background-Rationale

Such an evaluation, which relates equipment performance, support capability, etc., to specific mission objectives, requirements and applicable specifications, provides a firm basis upon which to evaluate the risk inherent in certifying equipment for a specific mission.

Such safety evaluations may also disclose the need for additional safety requirements. All such items so identified shall be documented and added to the existing baseline as are deemed necessary.

Approval

OMSF SAFETY REQUIREMENTS

Title		
POST-FLIGHT SAFETY EVALUATION	Effective Date	
	No. 1.7	Page No. 1 of 1

Statement of Requirement

Applicable Phase

Following each flight, the cognizant Program Safety Office shall conduct a safety evaluation which shall cover, but not be limited to, the following items:

a) Safety adequacy of procedures and protective equipment.

b) Response of warning devices and effectiveness of emergency procedures and equipment.

c) Identification of all anomalies and their effects.

d) Effects of human capabilities and constraints on Crew Safety.

A report of the evaluation shall be prepared and submitted to the Program Director and any other individual(s) he may designate.

Background-Rationale

A comprehensive post-flight safety evaluation report provides guidance in planning future missions and is essential to the establishment of necessary corrective action to reduce hazards.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
HUMAN ENGINEERING ON ALL CRITICAL END ITEMS		No. 1.8	Page No. 1 of 1
	Applicable Phase C		

Statement of Requirement

The design of critical end items shall be subjected to human engineering analysis in order to establish the highest level of man-machine relationship, to disclose potential hardware malfunction/failure resulting from human error, and to identify any potential hazard to personnel resulting from human error.

This analysis will evaluate the preliminary design in terms of how well the man will be able to operate and maintain his equipment under normal, emergency, fatigue, and illness conditions.

Background-Rationale

Identification and analysis of the overall hazardous consequences of a given failure event require an understanding of human capabilities and limitations as well as the interfaces between components, systems, and environments.

Approval

Title		Effective Date	
	SAFETY EVALUATION OF MAJOR CHANGES/MODIFICATIONS	No. 1.9	Page No. 1 of 1

Statement of Requirement

Applicable Phase
B, C, D

System Safety personnel shall evaluate all proposed changes/modifications to design, test, maintenance and mission operations which require review and approval at a key management checkpoint or Configuration Control Board. These safety evaluations shall encompass but not be limited to the following:

A. System/Subsystem/Equipment Hazard Analyses

B. Operating Hazard Analyses

The results of these hazard analyses shall be documented and presented for review at all subsequent management checkpoints, design reviews and Configuration Control Board meetings.

Background-Rationale

Safety considerations must be a factor in the decision to accept or reject a proposed change/modification.

The results of updated hazard analyses are essential if a thorough evaluation is to be made of the impact associated with the proposed change.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
SYSTEM SAFETY IN KEY MANAGEMENT CHECKPOINTS	No. 1.10	Page No. 1 of 3	

Statement of Requirement

Applicable Phase: A, B, C, D

System Safety shall be an integral part of all key management checkpoints and reviews (PRR, PDR, CDR, CI, COFW, DCR, FRR). Safety personnel at each checkpoint shall verify that all safety/man-rating requirements applicable to the phase of development have been incorporated and that a thorough hazard analysis has been conducted to identify possible emergency situations. All problems discovered in the various reviews/checkpoints shall be analyzed for corrective action and documented in a safety log. This safety log shall be presented for evaluation at all subsequent safety reviews.

Starting with the conceptual design phase of a program (PRR) and continuing throughout the design reviews (PDR's and CDR's), Configuration Inspections (CI's) and final configuration reviews (COFW's) the identification of hazards and the evaluation of potential emergency situations shall be centered in the following three areas:

1) Personnel - potential/existing hazards in manufacture, test, transport, storage, operation, and maintenance. These hazards include flamability limits, susceptibility to accidental explosion, production of noxious or toxic gases, use or production of hazardous chemicals, ease of access and exit, emergency exit, etc.

2) Equipment - failure/malfunction detection requirements and "failsafe" or emergency operation requirements. This shall include requirements for redundancy, interlocks, emergency and stand-by circuits, etc.

3) Induced Environment - limiting induced environment criteria. This shall include the induced environment requirements for transportability and storage such as noise, vibration, humidity and temperature limits.

Safety personnel shall provide assurance that the areas above have been thoroughly analyzed for each contractor or government supplied item. In providing such assurance, safety personnel shall utilize but not be limited to the following safety considerations.

1) Equipment compatibility and interface relationships.
2) Failure mode, effects and criticality analyses.

Approval

Title	Effective Date		
SYSTEM SAFETY IN KEY MANAGEMENT CHECKPOINTS		No. 1.10	Page No. 2 of 3

Statement of Requirement

Applicable Phase A, B, C, D

3) Analysis of circuit logic, models and packaging techniques.
4) Test, maintainability and manufacturing requirements and methods.
5) Qualification and acceptance test methods and inspection plans.
6) Specific qualification and acceptance tests results at the component, assembly, subsystem, module or system levels.
7) Failure reports, corrective actions and status of waivers and deviations.

During the final key management checkpoints (DCR's and FRR's) safety considerations shall be oriented toward examining the design of the total mission complex for development maturity and certifying the complex operationally ready for manned missions. During this phase of development more emphasis shall be placed on hazard identification at the mission level (see requirements 1.2 and 9.2). Specific safety considerations during these final management checkpoints shall include but not be limited to the following:

1) Hardware design and test history relating to all tests with data on failures, repetitive failures, corrective actions and unresolved problem areas.
2) Updated Failure Mode, Effects, and Criticality Analysis with emphasis on the identification and resolution of single failure points.
3) Correlation of performance/design margins in relation to mission critical parameters.
4) Summary of limited-life items versus mission requirements.
5) Status of procedures for emergency situations - adequacy and completeness of mission rules and contingency plans.
6) Proficiency certification and ability demonstrations of ground and flight crew performing hazardous operations.
7) System verification status and qualification test status.
8) Medical and recovery planning.
9) Previous missions post-flight safety data.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date
SYSTEM SAFETY IN KEY MANAGEMENT CHECKPOINTS	

No.	Page No.
1.10	3 of 3

Background-Rationale

Applicable Phase
A, B, C, D

Behind most accidents there is a cause that can be identified and eliminated. Since it is the role of System Safety to identify hazards and then eliminate or minimize the hazards to prevent accidents, it is essential to include System Safety Engineering in all phases of a program from conceptual design to mission completion. Requiring System Safety to be an integral part of all key management checkpoints, provides the opportunity for monitoring the application of safety/man-rating requirements and for evaluating the adequacy and completeness of existing hazard analyses. These reviews thus represent a means not only for monitoring current man-rating status, but also for maintaining man-rating control on each major end item.

PRR - Preliminary Requirements Review

PDR - Preliminary Design Review

CDR - Critical Design Review

CI - Certification Inspection

COFW - Certification of Flight Worthiness

DCR - Design Certification Review

FRR - Flight Readiness Review

Approval

Title	Effective Date		
SAFETY REQUIREMENTS FOR NEW MISSIONS		No. 1.11	Page No. 1 of 1

Statement of Requirement

Applicable Phase A, B

Each new mission shall be reviewed by the cognizant system safety activity to determine:

1) whether or not the mission objectives, anticipated environments, operations, maintenance, etc. are adequately covered by the currently existing safety requirements, and
2) if any existing safety requirements will impose constraints and restrict achievement of mission objectives or the development, operation, or maintenance of the mission hardware.

If the review discloses probable occurrence of either of the above conditions, the necessary new safety requirements shall be developed, approved, and issued and/or the appropriate waivers, deviations, modifications shall be recommended for approval by the OMSF Office of Safety.

Background-Rationale

As the scope of space intelligence increases and technological advances are made, safety must also undergo a parallel course of advancement. With the completion of each mission, new and improved techniques of hazard elimination and control will be developed and applied to succeeding missions. Accordingly, this collection of safety requirements will be maintained at an effectivity level commensurate with the state-of-the-art.

Approval

Title		Effective Date	
	CLASSIFICATION OF COMPONENTS, SYSTEM, HARDWARE	No. 2.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C

All components shall be classified as critical or non-critical, limited life, and cycle limited. Critical components should be failsafe and include redundancy and malfunction detection in their design where design feasibility allows and be capable of being maintained and/or repaired for long duration missions. Since the criticality of components may vary with application, e.g., boarding ladder on Lunar Module (LM) would not be critical in a earth orbit exercise of LM, but would be on lunar surface, likewise landing legs, ascent engine, etc., a system of time-accounting shall be maintained which will provide current criticality status of all components. All components must be classified, clearly marked on the item itself, tagged or stored in a marked bin, and documented to preclude the possibility that a limited life item will be used after its lifetime and to prevent substitution of non-critical items for critical ones when such a substitution is possible.

Background-Rationale

The failure of critical, limited life, and cycle limited components can adversely affect crew safety, result in not achieving a primary mission objective, or cause a launch scrub. The classification and marking of such components will establish the application of stringent test requirements and the appropriate high degree of care in handling and storage.

Approval

OMSF SAFETY REQUIREMENTS

Title	HIGH DEGREE OF EMPHASIS ON FMEA APPLIED TO CRITICAL COMPONENTS	Effective Date	
		No. 2.2	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C

Failure mode and effects analysis shall be applied to critical components in accordance with the Apollo Reliability and Quality Assurance Program Plan, NHB 5300.1A and NASA Policy Directive NPD 5300.7.

Background-Rationale

This emphasis on FMEA is an essential step in the overall process of successfully refining critical components and is of particular importance to the validity of the final certification that the components are suitable and acceptable for man use.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date
HIGH DEGREE OF EMPHASIS ON QUALITY CONTROL APPLIED TO CRITICAL COMPONENTS	No. 2.3	Page No. 1 of 1

Statement of Requirement

Applicable Phase
B, C

The establishment of quality control requirements through quality evaluation shall be of the highest order commensurate with the state-of-the-art, and program safety goals. They shall exceed currently accepted practices when such practices are considered inadequate or marginal for critical components.

Background-Rationale

Since the reliability goals established for manned space systems are of a high order, it is axiomatic that the quality control must be of an equally high order to achieve these goals. A rigid quality program, with equal emphasis applied to all phases of a system life cycle, provides the mechanism by which effective and total control can be maintained, and which provides the tangible assurance that system performance and reliability have not been compromised. Furthermore it enables prompt detection of deficiencies, incompatibility, marginal quality, etc.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
APPORTIONMENT OF MAJOR END ITEM QUANTITATIVE RELIABILITY GOALS		2.4	1 of 1

Statement of Requirement

Applicable Phase

B, C

Specific quantitative goals for the reliability of the major elements (e.g., launch vehicle, spacecraft) of a space vehicle system shall be identified prior to the design and development of the actual hardware and in consonance with the accepted mission risk. These reliability values shall be apportioned for the respective systems and subsystems comprising each major element with due consideration for the risk exposure and risk contribution of each system and subsystem.

Background-Rationale

To insure that adequate attention is directed to reliability in the design stage, it is desirable to specify an overall numerical reliability goal. This goal should be apportioned or budgeted through a mathematical model down to the various subsystems. The subsystem designer can then analyze these apportionments and determine which configuration of equipments can best meet the specified reliability goals.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
VEHICLE QUALITATIVE RELIABILITY GOALS		No. 2.5	Page No. 1 of 1

Statement of Requirement

Applicable Phase: B, C, D

The ultimate goal for manned vehicle reliability and flight crew safety shall be the following:

A. A single failure in any subsystem shall not cause or require abort of the mission.
B. A single failure or malfunction in a subsystem or component shall not cause the loss of life of the crew.
C. All equipment classified as critical must be fail-safe and include redundancy and failure-malfunction detection in its design.
D. Vehicles used on long duration missions shall require, in addition to items a,b, and c above, the following: automatic fault isolation and damage control, trend evaluation, and maintainability incorporated into the design of critical hardware.

If feasibility precludes achievement of one or more of these goals, proper approval must be obtained at the appropriate management checkpoint.

Background-Rationale

Mission costs, complexity, and astronaut's survival require this design approach. Unanticipated failure modes not considered in the reliability analysis occur with sufficient frequency to make high design reliability estimates unacceptable as a substitute for redundancy, failure detection and isolation, and maintainability resulting from this equipment.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
IDENTIFICATION OF COMPONENTS REQUIRING REDUNDANCE		No. 2.6	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C

There shall be identification of components requiring redundance and a determination of the extent of redundancy. A list shall be provided of non-redundant components, other than the spacecraft structure and heat shield for which design feasibility precludes redundancy, and whose failure would cause loss of the crew or require abort of the mission. A justification for use of each such component shall also be required.

Background-Rationale

To ensure maximum safety and mission success consistent with costs, complexity, mission objectives, and weight.

Approval

OMSF SAFETY REQUIREMENTS

Title	SEPARATION OF REDUNDANT PATHS	Effective Date	
		No. 2.7	Page No. 1 of 1

Statement of Requirement

Applicable Phase C

Redundant paths, systems, and components such as fluid lines, electrical wiring, connectors, explosive trains, and indicators shall be located to ensure that an event which damages one path is not likely to damage the other path and they shall not be connected to a common point whenever design feasibility permits.

Background-Rationale

A single failure resulting in the loss of all redundant paths, eliminates redundancy. Therefore, redundancy, in this instance, will not satisfy the redundancy requirements specified by Safety Requirement Nos. 2.5 and 2.6.

Approval

OMSF SAFETY REQUIREMENTS

Title	VERIFICATION OF OPERATION OF REDUNDANT PATHS	Effective Date	
		No. 2.8	Page No. 1 of 1

Statement of Requirement

Applicable Phase C, D

The design of spacecraft systems and subsystems incorporating redundancies shall include a means of verifying satisfactory operation of each redundant path during test and checkout, including a means of flight verification on long duration missions.

Background-Rationale

Verification of system operation does not necessarily indicate satisfactory operation of all redundant paths unless each path is tested or checked out separately. Satisfactory operation is interpreted to include functioning of all redundant elements in each redundant path.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	
RELIABILITY PREDICTION MODELS	No. 2.9	Page No. 1 of 1

Statement of Requirement

Applicable Phase

B, C

Predictions of reliability for system hardware shall be initiated early in the conceptual design stage and shall be continued on a periodic basis. Reliability prediction models shall be utilized until data from similar equipment or directly applicable test data becomes available.

Background-Rationale

The utilization of reliability models for predictions provides an early indication of the status of reliability. Analysis of these predictions serve to isolate major areas of system and mission unreliability and identify aspects of the hardware and mission most amenable to reliability improvement.

Approval

Title	Effective Date		
IDENTIFICATION OF NON-FLIGHT HARDWARE AND EQUIPMENT		No. 2.10	Page No. 1 of 1

Statement of Requirement

Applicable Phase
D

Hardware or equipment which is not suitable for use in flight, and which could be accidentally substituted for flight articles, shall be identified in a way that will prevent such substitution.

The method selected for identifying flight equipment which is not acceptable for flight use will be based upon size and configuration. The equipment shall be red striped with material compatible red paint. In the event the equipment is too small and it cannot be easily striped, it shall be tagged with an appropriate red tag, and the tag conspicuously marked "NOT FOR FLIGHT USE."

Background-Rationale

Non-flight hardware and equipment must be identified to preclude possible use in flight vehicles.

Approval

Title	Effective Date	No.	Page No.
WARNING SYSTEMS		3.2	1 of 1

Statement of Requirement

Applicable Phase: B, C

There shall be hazard warning systems to provide notice of operational anomalies, and impending hazards. These systems shall include an abort command capability and where feasible shall have automatic actuation in response to types of malfunctions where catastrophic failure is imminent, and manual actuation by astronaut or ground monitors during all phases of the mission when the nature of the malfunction makes this procedure more desirable. These systems shall also include self-verification of fault indicators, reset and/or replacement capability for reporting hazard reoccurrence.

Background-Rationale

During periods of extreme stress, such as encountered during launch, and when a malfunction would produce an imminent catastrophic failure, automatic abort actuation is required. During other phases of a flight an abort may not be the correct response under a particular set of circumstances. Long duration and deep space mission may require devices which do more than warn of hazards and initiate aborts; such devices would provide automatic corrective action, fault isolation, and trend evaluation.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
AUTOMATIC CONTROL WITH MANUAL BACKUP		No. 3.1	Page No. 1 of 1
	Applicable Phase B, C		

Statement of Requirement

The automatic attitude and translational control of any manned vehicle shall have manual backup.

Background-Rationale

Should the automatic system fail, the man will serve as backup and therefore increase mission reliability and redundancy.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
EMERGENCY BREATHING APPARATUS		No. 3.3	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C, D

Emergency breathing apparatus shall be provided and shall be readily accessible to test personnel and crew members in all flight, pre-launch and test facilities where an emergency situation might interfere with the respiration of personnel during tests.

Background-Rationale

Instances have occurred where emergency breathing apparatus either has not been available or has been placed in locations which were inaccessible during emergency situations.

Approval

OMSF SAFETY REQUIREMENTS

Title		
CHECKOUT AND VERIFICATION, EASE AND CAPABILITY	Effective Date	
	No. 4.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C

All flight equipment shall be designed with features that contribute to the ease and rapidity of checkout, maintenance and verification of operation, both inflight and on the ground. Equipment expected to require servicing or maintenance shall be designed to be accessible without removal of other equipment, wire bundles, and fluid lines unless specific approval from the program office is obtained.

Background-Rationale

Equipment must not only be designed to operate, it must also be designed to be checked to verify that it is operating or ready to operate. Designing for ease of checkout, maintenance and verification aids in minimizing the probability of equipment damage and/or personnel injury. On long duration missions the capability of inflight checkout, maintenance and verification will contribute to mission success and crew safety.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
CONTAINERS AND ENCLOSURES USED IN PRESSURIZED COMPARTMENTS		No. 4.2	Page No. 1 of 1

Statement of Requirement

Applicable Phase

Equipment containers or enclosures for use within the spacecraft pressurized compartments shall withstand rapid decompression associated with the opening of the largest opening in the spacecraft to the space environment.

Background-Rationale

Some provision must be made to ensure sealed containers inside the spacecraft will not burst when large vents such as hatches or doors are opened in a vacuum environment either in space or in test chambers.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
PREVENTION, DETECTION, AND SUPPRESSION OF HYDROGEN EXPLOSIONS		No. 4.3	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

When hydrogen is used as a propellant in rocket engines, steps shall be taken to make the propulsion system as gas tight as possible, to dilute and sweep away any hydrogen that has leaked either from the launch vehicle or ground support equipment, to insure that no open flames or spark producing equipment is used in the area, and to insure that adequate fire detection equipment is installed.

Background-Rationale

Hydrogen presents a very dangerous safety hazard. With the proper mixture of air and in a confined area, the possibility of explosion is very high. In an open area, hydrogen will burn with a very hot colorless flame which can cause very serious burns to personnel before they realize that a fire exists.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
PROTECTION AGAINST DEBRIS		4.4	1 of 1

Statement of Requirement

Applicable Phase: C, D

Every possible precaution should be taken during all phases of spacecraft development, manufacturing, and flight to eliminate and prevent introduction of debris into the spacecraft cabin and to eliminate or protect areas where debris might collect.

Background-Rationale

In a zero-g environment debris will tend to float around and possibly damage critical equipment (cause short circuits in electrical equipment, plug vents, etc.) or endanger the crew.

Approval

Title	Effective Date		
RELIEF VALVES		No. 4.5	Page No. 1 of 1
	Applicable Phase C, D		

Statement of Requirement

Relief valves set at a level between burst pressure and the system operating pressure shall be installed. This level shall be determined so as to give the maximum degree of safety to all personnel. No other restricting device will be allowed upstream of the relief valve. The relief valve should be large enough to relieve the system faster than the source can pressurize it and shall be positioned so that it does not relieve the system into a closed area, so that nothing interfers with its operation, so that it cannot be opened by accident, and so that personnel working in the area are not endangered by its operation.

Background-Rationale

Instances have occurred where improper design and placement of relief valves have compromised crew and test personnel safety.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
OPERATIONAL-STATUS MONITORING SYSTEM		No. 4.6	Page No. 1 of 1

Statement of Requirement

Applicable Phase: Phase C

Incorporate a continuous monitoring system which periodically (in relatively short increments) indicates the operational status of all on-board systems.

Background-Rationale

A monitor system of this type is used to show the status of systems with relatively long periods of time between usage or those which are not used at all until the last phases of the mission. By having these indications, possible emergency situations can be predicted and countered.

Approval

Title	Effective Date	
EXTRAVEHICULAR SPACE SUITS	No. 4.7	Page No. 1 of 2

Statement of Requirement

Applicable Phase C

Design of Extravehicular Space Suits shall include:

1. Secondary pressure protection should a failure or break occur in the primary pressur-retaining layer.
2. Entrance closures shall be more reliable than a zipper chain, backed by molded rubber lips which provide sealing. (Pressure-sealing slide fastener)
3. An emergency portable life support system shall be provided for emergency operation should the primary system malfunction.
4. Suit assembly shall have an integrated over-garmet which will provide thermal insulation and micrometeoroid protection.
5. Greatest possible pressurized mobility must be provided in all areas of the body, i.e., arms, legs, torso, head, shoulders, feet, etc.
6. Donning, doffing, and stowage must be easily accomplished and integrated assembly testing must be provided.
7. Boot design shall accommodate surface temperatures and consider the condition of the sur face.
8. Suit ventilation systems shall be capable of removing excess body heat at all levels of work load, under both normal and emergency conditions. Any heat which causes injury or discomfort to the occupant is considered excessive.
9. Eye protection shall be provided to protect the wearer against glare, and excessive intensities of Ultra-Violet and Infra-Red radiation.
10. Voice communication, adequate to support emergency operations, shall be provided.
11. The environmental control system shall be provided with an oxygen partial pressure sensor and a carbon dioxide analyzer. Monitoring capability of these devices shall be

Approval

Title	EXTRAVEHICULAR SPACE SUITS	Effective Date	
		No. 4.7	Page No. 2 of 2

Statement of Requirement

Applicable Phase: C

provided to the suit wearer and/or preferably an astronaut not participating in extravehicular activity.

12. Special emphasis shall be given to the design of the environmental control system to prevent malfunction from injection of foreign matter into the air supply (i.e., vomit, dust, other debris).

Background-Rationale

Space suits have been designed to act primarily as a backup to the spacecraft cabin-pressurization system. Should the cabin become decompressed, the space suit takes over and protects the astronaut during reentry. The above requirements are primary for the lunar suit. Because of many unknowns in this area of spaceflight, there remains much data to be obtained, studied and interpreted for analysis and application to the design of a spacesuit for a specific application (i.e., lunar and/or planetary surface exploration, extravehicular activity for purposes of making spacecraft repairs).

Approval

Title	Effective Date
MATERIALS CONTROL AND SUBSTITUTION	No. 4.8 / Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

A rigid materials control system shall be established for all critical equipment. This system shall include requirements for certification that the substitute material meets the design specifications.

Background-Rationale

Materials used in manufacture of critical components must be certified to meet the appropriate specifications. No substitution shall be made unless the substitute material is similiarly tested and certified. Special effort must be made to control and account for all material substitutions made during all phases of launch vehicle and spacecraft development.

Approval

OMSF SAFETY REQUIREMENTS

Title		
HAZARDOUS MATERIALS IN THE SPACECRAFT CABIN	Effective Date	
	No. 4.9	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C, D

Items, such as the following, shall be excluded from the spacecraft cabin:

1. Materials capable of sustaining combustion in the spacecraft atmosphere.
2. Unprotected shatterable material. (Protection shall prevent particles from escaping into cabin.)
3. Coatings that are subject to flaking.
4. Unalloyed Beryllium. Alloys containing 4% or more of Beryllium shall not be machined in any way at any time in the spacecraft cabin.
5. Polyvinal Chloride (PVC).
6. Mercury where the possibility exists that it can enter cabin environment.
7. Materials that are toxic and toxic liquids under any anticipated conditions that the spacecraft cabin will be exposed to.
8. Experiments that have any of the previously mentioned materials associated with them.

Background-Rationale

The possibility exists that materials or objects may be installed within the cabin or brought on board as part of an experiment, which would either endanger or impair the performance of the crew, the mission, or some critical piece of equipment. Special care must be taken that this does not occur. Some materials (PVC) are used in manufacturing under various trade names where the actual nature of the material is not stated. All items must be clearly identified as to the type of materials used in its construction.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
SOLAR FLARE WARNING AND RADIATION PROTECTION		No. 4.10	Page No. 1 of 1

Statement of Requirement

Applicable Phase: A, B, C

Provision must be made to warn and/or shield against radiation from all sources (i.e., solar flares, Van Allen Radiation Belts and on-board sources such as nuclear propulsion and electrical power systems). Radiation shielding shall be provided for all passage of manned vehicles into or through the Van Allen Radiation Belts. Since solar flare frequency and intensities can not be accurately predicted, energy measuring devices shall be provided to warn of potential solar flare hazards and a means of indicating dosage received by the crew shall be provided inside the spacecraft.

Background-Rationale

Radiation presents a serious hazard to crew safety. Knowledge of a solar flare occurrence or measurement of its energy could provide the crew with enough time to determine if the energy of the Solar Flare Radiation is harmful and to take remedial action if necessary. A manned spacecraft cannot remain in the Van Allen Belts for any length of time unless shielding is provided.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date
METEOROID PROTECTION	No. 4.11	Page No. 1 of 1

Statement of Requirement

Applicable Phase: A, B, C

The spacecraft must be provided with meteoroid protection and a meteoroid puncture detection and location device.

Background-Rationale

Meteoroids represent a constant hazard in the space environment. A meteoroid bumper would provide some protection against small meteoroids or micro-meteoroids. For those which the bumper could not stop, the crew must know immediately when the cabin or other critical equipment has been damaged, so that the crew can make emergency repairs.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
DEVELOPMENT OF REFERENCE TRAJECTORIES FOR DESIGN		No. 4.12	Page No. 1 of 1

Statement of Requirement

Applicable Phase: A, B, C, D

Trajectory analysis and optimization shall be performed and a reference trajectory defined that contains vehicle rates and stress within structural limits and provide a trajectory baseline for vehicle design and development.

Background-Rationale

Trajectory data must be available to insure that flight loads do not exceed crew and equipment tolerances and structural limits. The vehicle flight path is required in order to develop adequate tracking and communication coverage, and to verify that the vehicle will be in position for deorbiting and landing in either the primary or contingency recovery areas. Contingency planning using the reference trajectory as a baseline will insure that backup procedures are available for safe abort during every mission phase. Review of the trajectory data will give assurance that the crew members are not exposed to radiation hazards.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	
CRITERIA FOR CLOSED CHAMBERS	No. 5.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase
B, C, D,

All operations involving personnel in a vacuum, oxygen-rich, or potentially oxygen rich environment, in closed test chambers or in other major test facilities shall conform to the criteria established in Attachment A, KMI 8610.6, March 25, 1968, MSCI 8825.1A, October 23, 1967 and all subsequent revisions of these documents.

Background-Rationale

Operations involving closed chambers presents a potentially hazardous situation. All criteria in the above mentioned documents must be adhered to, to prevent injury to test personnel.

<u>References</u>

1. "Operational Readiness Inspections," KMI 8610.6, Attachment A, Kennedy Space Center, March 25, 1968.

2. <u>Manned Spacecraft Center Management Instruction</u>, "Operational Readiness Inspections of MSC Test Facilities and Equipments, MSCI 8825.1A, October 23, 1967.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
STATIC DISCHARGES		5.2	1 of 1

Statement of Requirement

Applicable Phase
C, D

Personnel in oxygen-rich closed chambers shall wear non-static generating clothing. Precautions shall be taken to prevent static electricity buildup on equipment used in oxygen-rich closed chambers.

Background-Rationale

Tests have shown that static discharge can ignite powders and flammable gases and in some cases certain types of solid materials.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	
FIRE DETECTORS	No. 5.3	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

Overheat or rate of temperature rise indicating fire detectors are not suitable for use in oxygen-rich closed chambers. Fire detectors that depend on absolute temperature rise, flame radiation (ultra-violet or infra-red) sensing, or combustion product sensing are suitable for use in oxygen-rich closed chambers. Preferably two of these type flame detectors should be used together.

Background-Rationale

Overheat or rate of temperature rise fire detectors have a very slow response time and have a very limited volume coverage. It is essential to personnel safety that fires are detected as soon as possible.

Approval

Title	Effective Date	No.	Page No.
TOXIC VAPOR DETECTORS		5.4	1 of 1

Statement of Requirement

Applicable Phase: C, D

Toxic vapor detectors which give both an audio and visual warning shall be used in areas where there is a possibility of toxic gases being present.

Background-Rationale

An audio and visual warning device will insure that warnings of toxic vapor will not be overlooked or ignored.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date
VOICE COMMUNICATIONS	No. 5.5 — Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

Emergency equipment at launch, test, and training facilities shall be provided with voice communication adequate for supporting normal operations and rescue action during emergencies.

Background-Rationale

Voice communication is essential for proper and prompt rescue operations.

Approval

Title	Effective Date	No.	Page No.
PORTABLE FIRE EXTINGUISHERS		5.6	1 of 1

Statement of Requirement

Applicable Phase: C, D

Portable fire extinguishers for all types of fires shall be provided and readily accessible in manned space systems, launch, test, and training facilities. They shall also be clearly marked for the type of fires on which they are to be used and not produce toxic by-products.

Background-Rationale

In certain cases the proper extinguishers have not been provided or have been placed too close to possible sources of fire. Using the wrong extinguishers on certain kinds of fires will only spread the flames. Tests have shown that fire extinguishing agents such as Freon 1301 and Carbon Tetrachloride produce toxic fumes and gases under the influence of high temperatures.

Approval

OMSF SAFETY REQUIREMENTS

Title	REDUCTION OF FORCED CIRCULATION	Effective Date	
		No. 5.7	Page No. 1 of 1

Statement of Requirement

Applicable Phase C, D

Provisions for rapidly discontinuing forced circulation of atmosphere shall be made in all manned flight and ground facilities.

Background-Rationale

Forced circulation of atmosphere will spread fire and toxic fumes.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	
MAINTENANCE ANALYSIS	No. 6.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

Maintenance analysis shall be performed on all critical components and systems to identify all points of pre-flight, flight, and ground maintenance.

Background-Rationale

Maintenance analysis must be performed in order to insure that all points of maintenance are identified, what systems can be repaired during flight, that maintenance procedures are clearly established, and to insure that maintenance of one system will not damage another. In-flight maintenance will be of great importance on extended space mission in order to insure the safety of the crew.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	
MAINTENANCE OF PRESSURE VESSELS AND LINES	No. 6.2	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C, D

All pressure vessels and lines should be protected against external damage and/or regularly inspected for any signs of damage in the form of nicks or scratches which may tend to weaken the vessel, or line.

Background-Rationale

Nicks, scratches, or dents will weaken the walls of the vessel or the line, so that it may burst the next time it is used.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
HYDROSTATIC PROOF-TESTING		No. 6.3	Page No. 1 of 1

Statement of Requirement

Applicable Phase D

All items or components to be installed in pressure systems should be hydrostatically proof-tested and certified as to proof pressure prior to installation both initially and subsequent to modification or repair. These tests shall be repeated, when the components have been subjected to extreme heat, blast effects, physically damaged, or signs of corrosion or other deterioration is noticed. Personnel and equipment shall be adequately protected during these tests.

Background-Rationale

Pressure vessels are easily damaged. Switching a tank from a system of lower pressure to one of higher pressure has been done on occasion in the past. Before these tanks are used they must be tested for the pressure at which they are to be used.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
MAINTENANCE OF EGRESS EQUIPMENT		No. 6.4	Page No. 1 of 1

Statement of Requirement

Applicable Phase
D

Egress equipment used at the launch facility, closed chambers, test facilities, etc. which must be actuated (hatches, doors, etc.) either automatically, manually or manually initiated shall be tested for operational adequacy in all modes periodically and immediately prior to prelaunch or performance of tests. Time relative to the operation shall be recorded and evaluated.

Background-Rationale

Experience has shown that in some instances egress equipment was inoperative or the time needed to operate it was not consistent with the applicable emergency procedures.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
DAMAGE RESULTING FROM EXERCISE OF EMERGENCY EQUIPMENT		6.5	1 of 1

Statement of Requirement

Applicable Phase
D

All manned flight and ground equipment intended for repetitive use shall be subjected to a performance check immediately following emergency exercises in order to insure that no damage was sustained.

Background-Rationale

It is essential to see that no damage to the equipment results from the emergency exercise. A performance check will show whether or not this has happened.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
SHIPPING AND TRANSPORTATION DAMAGE		No. 6.6	Page No. 1 of 1

Statement of Requirement

Applicable Phase: D

All critical equipment sensitive to temperature, pressure, humidity, or shock, shall be shipped or transported with devices which will indicate if any of the above conditions have exceeded equipment specifications.

Background-Rationale

Critical equipment and hardware can be damaged in shipping or transportation. Since the damage may not be readily apparent, an instrument or recording device must be used to determine if the equipment has experienced any condition which may be detrimental to its safe operation.

Approval

REQUIREMENTS

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PREPARATION

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
QUALIFICATION OF CRITICAL VENDOR ITEMS		No. 8.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C, D

Off-the-shelf vendor items shall be qualified for manned space system application by NASA or a cognizant NASA contractor. Method of qualification (similarity analysis, demonstration, test) shall be determined by the criticality of the item and the environment in which it will function. A history of satisfactory performance in commercial applications will not be acceptable in lieu of formal NASA qualification.

Background-Rationale

Qualification merely by past performance can result in non-qualified items being passed as qualified unless standard procedures are used. These would insure that there have been no changes in the product itself, fabrication methods, inspection techniques, manufacturing environment, test and electromagnetic interference.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
QUALIFICATION, ACCEPTANCE, AND INTEGRATED SYSTEMS TEST COMPLETION		No. 8.2	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C, D

Qualification, acceptance testing, and integrated systems testing must be satisfactorily completed before prelaunch checkout, except for those integrated systems tests which are normally conducted as part of prelaunch checkout. Integrated systems tests shall verify that all flight systems will meet mission performance requirements as an integrated "system" and are physically and operationally compatible with mating hardware and GSE.

Background-Rationale

Items which have not met mission performance requirements present not only a possible hazard to personnel at the launch center, but create delays in the launch itself. Every effort must be made to insure that equipment, when it arrives at the launch center, is ready to begin pre-launch checkout. Integrated systems tests insure that all systems are compatible with each other and with major components of ground support equipment. One of the most important aspects of integrated systems tests is to insure at a relatively early stage that all sources of electro-mechanical interference between systems are eliminated.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
ADEQUATE COMMUNICATIONS FOR HAZARDOUS TESTS AND OPERATIONS		8.3	1 of 1

Statement of Requirement

Applicable Phase

C, D

Tests, training, and operations involving possible risk to personnel shall not be conducted unless communications (voice, visual, etc.) are adequate to support emergency operations, and protective equipment (pressure suits, fire suits, etc.) is provided for all foreseeable emergency situations. If possible, several forms of communication should be available, i.e., radio, telephone, visual, etc. Protective equipments must not only be complete but must also be readily accessible.

Background-Rationale

Communication in the sense used here is taken to mean any form of contact between personnel in the facility and outside emergency personnel. Lack of communications capability can seriously delay rescue operations. Furthermore, with adequate communications capability, the personnel subjected to the emergency can direct or guide rescue operations.

Approval

Title	Effective Date	No.	Page No.
SUBSTANTIATION OF TEST CONCLUSIONS		8.4	1 of 1

Statement of Requirement

Applicable Phase: C, D

Conclusions derived from tests, and subsequent redesign and testing must be clearly and adequately substantiated by valid and specific test result data.

Background-Rationale

A tendency to read into test data, conclusions which are not really there, has been common in the past. Conclusions drawn from test result data must be valid in order to insure the safety of the flight crews.

Approval

OMSF SAFETY REQUIREMENTS

Title	UNMANNED VERIFICATION FLIGHTS	Effective Date	
		No. 8.5	Page No. 1 of 1

Statement of Requirement

Applicable Phase B, C, D

Each new generation of space vehicles, launch vehicles and spacecraft will require at least one unmanned flight to provide verification of system and structural integrity under all conditions that will be normally encountered in the manned mission. The data derived from this unmanned flight will be evaluated to determine if there were any anomalies, and if so, what must be done to insure the safety of the crew on subsequent flights. Any anomalies found must be corrected, or the mission itself must be altered. Examples of generations of space equipment are, Mercury capsule with its Atlas Booster, Gemini capsule with its Titan II booster, Apollo (CM and LM) with both the Saturn IB and Saturn V, the MOL program with the Laboratory, the Gemini capsule and the Tital III booster. Each major component (Launch vehicle (Atlas, Titan, Saturn IB-V, etc.), Spacecraft (LM, CM, etc.)) must be flown successfully unmanned at least once before it can be considered to be safety evaluated.

Background-Rationale

Because of the requirement for lightness, launch vehicle tanks, adapters, and the spacecraft itself are all susceptible to rather large distortions under load. During the atmospheric phase of flight, dynamic pressures approach 1000 pounds per square foot at Mach numbers in the transonic speed range. Under these conditions fluctuating pressure distribution may produce rather severe buffeting loads and fluctuating wakes. This was demonstrated early in the Mercury development flights where structural reinforcement or redesign was required to prevent failure, or where increased clearances had to be provided to prevent serious interference or damage under load.

Approval

OMSF SAFETY REQUIREMENTS

Title	RELIABILITY DEMONSTRATION TESTS
Effective Date	
No.	8.6
Page No.	1 of 1
Applicable Phase	C, D

Statement of Requirement

A rigorous reliability testing program shall be conducted at the lowest practical hardware generation level for those items identified as critical components.

Background-Rationale

Reliability estimates (assessments) are derived from results of reliability demonstration tests. These estimates, when compared to predicted reliability estimates and approtioned reliability goals, provide an indication of whether a satisfactory level of reliability, consistent with identified hazards has been achieved. Such a procedure of test, assessment, comparison and evaluation helps to establish a high level of engineering confidence in the capability of critical hardware to perform their intended functions.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
QUALIFICATION OF FLIGHT EQUIPMENT IN SIMULATED ENVIRONMENT		No. 8.7	Page No. 1 of 1

Applicable Phase: C, D

Statement of Requirement

All flight equipment shall be flight qualified in a simulated flight environment. If existing facilities are inadequate, modifications or new facilities must be employed. If simulation is beyond the state-of-the-art, mission objectives and plans must be re-evaluated or a scaled down model might be used (flight equipment too large).

Background-Rationale

Flight equipment must be tested in the environment to which it will be exposed in order to gain a thorough understanding of its reaction to the environment. Many of the conditions encountered in flight are new and there is yet little knowledge concerning these conditions and the reactions of a material or equipment to these conditions.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date
PRESSURIZATION/DEPRESSURIZATION OF HARDWARE	No. 8.8	Page No. 1 of 1

Statement of Requirement

Applicable Phase C, D

A pressurization/depressurization time in seconds shall be certified by actual test for each item of space and test hardware which is intended to contain personnel for all anticipated situations, emergency or operational. Pressurization/depressurization time must be within those limits required to assure the safety of contained personnel in emergency situations.

Background-Rationale

Knowledge of the time for pressurization/depressurization is necessary to plan emergency procedures and to insure that the crew can take emergency actions in the time available for an abort or to insure that the cabin can be pressurized in time to prevent suffocation should there be a malfunction in the pressure suit circuit.

Approval

OMSF SAFETY REQUIREMENTS

Title		
QUALIFICATION OF TEST EQUIPMENT USED IN CLOSED CHAMBERS	Effective Date	
	No. 8.9	Page No. 1 of 1

Applicable Phase: C, D

Statement of Requirement

All test equipment used in closed chambers must be fully qualified for use under all forseeable test or emergency conditions which can occur in the chamber. Equipment to be tested must be at least conditionally qualified for use in closed chambers. An article is conditionally qualified when it has successfully passed all previous tests in the test plan. The test plan should be organized so that initial testing will point up as much as possible any failurewhich if it occurred in a closed chamber would endanger the test personnel.

Background-Rationale

Experience has shown that there is a tendency to use non-qualified items in closed chambers. The test articles must be analyzed to insure that the possible failure modes in the chamber, will not be catastrophic.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date	
QUALIFICATION OF PRESSURE VESSELS		No. 8.10	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

Pressure vessels must be tested and qualified under all conditions anticipated in use and shall abide by the standards established in MSC's "Procedural Standards Bulletin," Nos. PS-38, Rev. A, PS-39.

Background-Rationale

In the past, operations such as cleaning, flushing, and purging were not always included as part of the qualification testing. As a result, the fliuds, gases, or pressures (above normal operational pressure) used in these operations were not compatible with the materials used in the construction of the vessels and have caused a serious degradation in the structural integrity of the pressure vessels.

References: Manned Spacecraft Criteria and Standards, "Procedural Standards Bulletin," Nos. PS-38, Rev. A, PS-39.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
TEST PROCEDURE ANALYSIS AND CONTROL		No. 8.11	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C, D

A. Test procedures shall be analyzed to assure that conditions hazardous to the system and to test personnel are not set up, and that instructions are clearly and concisely written. All procedures shall be checked against the hardware and all involved equipment prior to actual tests.

B. Positive control shall be exercised to assure that deviations from test procedures are held within limits of the test objectives and that the deviations are analyzed to assure that they do not set up a series of events which are out of proper sequence.

Background-Rationale

Assurance of test personnel safety can be attained only by complete knowledge of the actions of each person involved in a given test procedure.

Poorly written or vague procedures are one of the major causes of accidents and incidents in test and space vehicle operation. They represent as great a threat to safety as do faulty hardware and careless work. Nothing should be left to the imagination or be left out because it seems "obvious."

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
CERTIFICATION OF SYSTEM CONFIGURATION FOR TESTS		8.12	1 of 1

Statement of Requirement

Applicable Phase
D

The configuration of the system subjected to each specific test shall be certified that it is the required configuration for the specific test prior to the beginning of the test.

Background-Rationale

Configuration certification of system to be tested is necessary in order to derive results which are representative of design specifications, and to assure accurate performance and reliability test results for the operational configurations.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
TEST CREW UNDERSTANDING OF TEST		8.13	1 of 1

Applicable Phase: D

Statement of Requirement

Test crews shall have a thorough understanding, prior to beginning a test, of the mechanics of each test and what the test is to demonstrate.

Background-Rationale

Tests cannot be properly and safely conducted unless the test crew is aware of the mechanics and objectives. If this is not done injury to the test crew or erroneous test results may result.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	
ELECTROMAGNETIC INTERFERENCE	No. 8.14	Page No. 1 of 1

Statement of Requirement

Applicable Phase
B, C, D

A complete integrated system electromagnetic interference test shall be performed on all spacecraft at progressive stages in spacecraft development.

Background-Rationale

These tests are necessary to insure that all telemetry, communication, and radar units will not interfere with each other. This type of interference, especially in the communication and radar systems, presents a potential crew hazard.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
UNEXPLAINED EQUIPMENT DIFFICULTIES		9.1	1 of 1

Statement of Requirement

Applicable Phase
D

A manned mission or test shall not employ any equipment which has exhibited any difficulty unexplained or uncorrected during development and preflight tests.

Background-Rationale

Where the cause of an inconsistency remains unresolved, equipment is unreliable.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date	
MISSION EMERGENCY PROCEDURES		No. 9.2	Page No. 1 of 1
Statement of Requirement		Applicable Phase C, D	

For each mission, an identification, and description of foreseeable emergency situations shall be made. Corrective procedures shall be developed for each emergency. Emergencies shall be considered to arise from:

a. System failure
b. Environmental hazards
c. Personnel error
d. Personnel illness
e. Psychological disturbance

Background-Rationale

Identification of all hazards and development of abort or corrective procedures is necessary for mission success and crew safety. Care must be taken to include all hazard sources which previous testing has uncovered or hazards which could not be eliminated in the design phase of hardware development.

Approval

OMSF SAFETY REQUIREMENTS

Title		
EMERGENCY ESCAPE PROVISIONS	Effective Date	
	No. 9.3	Page No. 1 of 1

Statement of Requirement

Applicable Phase
C, D

Suitable provisions shall be made for astronaut escape, separation, and recovery during:

a. Prelaunch
b. Launch
c. Flight
d. Orbit
e. Re-entry
f. Mission termination

Rescue provisions shall include capability for recovery at the pad, in flight, from the ground, and from water. During long duration, deep space missions, manned space systems shall have a separate compartmentized area to retreat to in case of difficulty without abandoning the mission. These areas shall have remote reporting on system status and remote, automatic and manual damage control and corrective action capability.

Background-Rationale

Adequate escape provisions must be formulated to cover all phases of the mission, and from any conditions which the crew may find themselves after an abort. Experience has shown that some areas of the mission have been neglected, and that inadequate provisions may exist for rescue from the terminal phase of an abort from the launch pad.

During long duration, deep space missions, it may be neither practical nor feasible to initiate astronaut escape and recovery.

Approval

OMSF SAFETY REQUIREMENTS

Title	EMERGENCY EGRESS GROUND RULES	Effective Date	
		No. 9.4	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

A set of ground rules shall be developed for each mission covering usage of Normal, Emergency Egress, and Launch Escape System (LES) Abort modes of crew removal in the event of pre-launch contingencies. The effectiveness of these rules shall be verified by tests, cognizant personnel, and crews trained in the correct procedures and operation of any required equipment. These rules shall be included in the Launch Mission Rules Document.

Background-Rationale

Egress ground rules must be included in the mission rules in order to insure that all personnel are aware of the correct and proper procedures.

References: "Bellcomm Status Report: On-Pad Crew Safety - Case 320, 9/29/66"

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
EMERGENCY CONCERN PERIOD		No. 9.5	Page No. 1 of 1

Statement of Requirement

Applicable Phase
D

The period of emergency concern for a given mission shall start from the time of terminal countdown.

Background-Rationale

Terminal countdown on manned missions shall be considered to start when the crew arrives at the launch pad.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date
ABORT PROCEDURES	No. 9.6	Page No. 1 of 1

Statement of Requirement

Applicable Phase C, D

Abort procedures for given emergencies in any mission phase shall be developed and periodically exercised or otherwise validated.

Background-Rationale

Exercise and validation is necessary to ensure that all personnel are aware of the correct procedures and that there are no unanticipated problems.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
OPERATION OF SIMULATION EXERCISES		No. 9.7	Page No. 1 of 1

Statement of Requirement

Applicable Phase
D

Critical mission phases shall be simulated prior to each mission. Mission conditions shall be simulated as closely as known data allows. Simulations shall not only consider equipment, but shall focus on crew performance, physiological, interpersonal aspects, and total system performance. Four areas of crew activity shall be stressed.

a. Physiological and psychological responses to altered atmospheres and environment.

b. Measurements of crew performance of flight tasks.

c. Conduct of experimental tasks.

d. Personal and interpersonal reactions.

The results derived from the simulation exercise shall be evaluated against mission requirements as to readiness of crew, probability of mission success, and adequacy of hardware.

Background-Rationale

Basic requirements are the selection of an atmosphere and determination of its acceptability. Much information can be obtained from long-duration simulations which would be useful early in the program for verification of anticipated results or for identification of potential problem areas. Information will also be obtained on the effects of long duration exposure to certain aspects of the space environment, i.e., weightlessness, low magnetic field strength, etc. Later phases of simulation exercises will include detailed simulations using actual flight hardware.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date	
COORDINATION AND APPROVAL OF DOCUMENTATION		No. 10.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase
A, B, C, D

All requirements, planning and procedural documentation applicable to critical components must undergo an established coordination and approval process and be subject to a formal updating, revision and accounting system.

Background-Rationale

Approved planning and procedural documentation is necessary to insure that all applicable data is approved and is available to support training activities, safety analysis, hazard analysis, and test procedure development. This data must be in an accounting system which makes the data and documents easily available to anybody that needs them when they need them. Failure to follow these requirements can result in major hazards being overlooked and delays in the overall program.

Approval

Title	Effective Date	No.	Page No.
INCORPORATION OF DESIGN AND CONFIGURATION CHANGES INTO APPLICABLE DOCUMENTATION		10.2	1 of 1

Statement of Requirement

Applicable Phase: C, D

Design and configuration changes shall be incorporated into applicable test, maintenance, and operation documentation whenever such changes require modification to established testing operations and maintenance.

Background-Rationale

Undocumented design and configuration changes can result in invalid test result data; damage to equipment from improper procedures; injury to test, operation or maintenance personnel; and schedule slippage.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date	
TRAINING PROGRAMS FOR TEST PERSONNEL		No. 11.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase D

Test and operations organizations shall be responsible for developing minimum training standards for conducting training programs for the purpose of qualification and certification of all operating and test crew personnel.

Background-Rationale

Training is an essential part of safety. Test and operating personnel must be fully aware of all test, operating, and emergency procedures. They must also be fully aware of the hazards associated with the equipment being operated.

Approval

Title	Effective Date		
PERSONNEL SUBSYSTEMS		No. 11.2	Page No. 1 of 1

Statement of Requirement

Applicable Phase
A, B, C, D

Personnel subsystems shall be developed for all manned missions. These subsystems will establish the requirements for all positions, skills, operational and maintenance procedures, training, and personnel certification. The personnel subsystems will apply to both flight and ground functions. Appropriate documentation such as position guides, job procedures, training material, and operations/maintenance manuals shall be selected and/or developed as part of the personnel subsystem.

Background-Rationale

A formally organized personnel subsystem insures the timely availability of qualified, certified personnel. By utilization of such people, each mission task is performed with a high level of efficiency which, in turn, is a practical extension of quality control. Also, qualified personnel are capable of recognizing conditions which may be threats to safety and which may not be recognized by non-qualified individuals.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date	No.	Page No.
PERSONNEL INCENTIVE PROGRAM		11.3	1 of 1

Statement of Requirement

Applicable Phase
A, B, C, D

A personnel incentive program shall be implemented which shall create an awareness of the importance, need, and seriousness of safety. It shall serve to instill a sense of pride, efficiency, and conscientious effort within all personnel involved in the development, manufacture, test, maintenance, and operation of equipment, software (documentation) and facilities.

Background-Rationale

Although designing a component or system to man-rating or safety criteria is the most effective way of applying man-rating criteria, the human element plays an important role as long as his awareness is constantly reinforced.

Approval

Title	Effective Date	No.	Page No.
TRAINING HARDWARE		11.4	1 of 1

Statement of Requirement

Applicable Phase: C, D

Crew training shall consist of a well balanced progressive program which develops from classroom instruction through mission simulation by utilizing operational or mock-up hardware and spacecraft simulators. Verbal or graphic training aids shall not be considered sufficient for assurance of crew safety.

Background-Rationale

The most effective type of training that can be provided is through the use of operational or mock-up equipment. Skill in the use of controls and determination of reaction times cannot be acquired with any other type of training equipment.

Approval

OMSF SAFETY REQUIREMENTS

Title	Effective Date		
FLIGHT HARDWARE-RESTRICTION ON USE FOR TRAINING	No. 11.5	Page No. 1 of 1	Applicable Phase D

Statement of Requirement

Hardware and equipment which is scheduled as primary or spare equipment for flight shall not be used for training unless all of the following conditions are met:

a. Training use is strictly limited to the prime and back-up flight crews.

b. Adequate crew familiarity with the characteristics of the actual flight equipment cannot be obtained from fabrication and use of training models.

c. The equipment will subsequently be subjected to all inspections, and pre-installation and preflight tests, required of new equipment.

d. After such training use, the life remaining on all limited life items will be adequate for completion of the mission.

Background-Rationale

To minimize the risk of undetected damage occurring before being used for flight.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date
SELECTION OF FLIGHT CREWS	No. 12.1	Page No. 1 of 1

Statement of Requirement

Applicable Phase: C, D

Selection of flight crews for space flight shall be based primarily on medical qualifications with particular emphasis on susceptibility to known or possible biological and mental effects of space flight conditions, and secondarily on possession of necessary skills and knowledge.

Background-Rationale

Physical and mental fitness are prerequisites to survival in space. To perform the required flight and scientific tasks, a great deal of knowledge and skill is necessary. Individuals who become incapacitated because of sensitivity to conditions peculiar to space flight (weightlessness, variation in magnetic fields, claustrophobia, etc.) present a serious hazard to the safety of other crewmen.

Approval

OMSF SAFETY REQUIREMENTS

Title	MEDICAL SUPERVISION	Effective Date	
		No. 12.2	Page No. 1 of 1

Statement of Requirement

Applicable Phase
A, B, C, D

All space related activities involving man in environments which are potentially hazardous shall be supervised by medical personnel who have proven knowledge and experience in Aerospace Medicine. Flight crews shall work closely with the appropriate medical personnel and on flights of long duration medical personnel shall be included as part of the flight crew.

Background-Rationale

Space flight and associated ground activities involve environmental conditions which are both relatively new and unknown, and which are potentially hazardous to man. Medical supervision is required to insure that the personnel, both ground and flight, are not seriously endangered by these activities. On long duration interplanetary space flights, it will not be possible to make an immediate return to earth to seek medical care, should the crew be injured or become seriously ill. Therefore, a doctor must be available to render immediate medical assistance.

Approval

OMSF SAFETY REQUIREMENTS

Title	ROUTINE MEDICAL MONITORING	Effective Date	
		No. 12.3	Page No. 1 of 1

Statement of Requirement

Applicable Phase D

Routine medical monitoring of critical biological functions (heart beat, blood pressure, prespiration, brain function, etc.) shall be required on all space missions. This monitoring shall occur at frequent enough intervals in order to identify possible medical emergencies before the health of the crew is seriously affected. On long duration missions the on-board medical personnel shall perform the monitoring of bodily functions if the wearing of the necessary medical sensors would be uncomfortable over long periods of time.

Background-Rationale

Medical monitoring is a necessity in order to insure survival of the crew and success of the mission.

Approval

OMSF SAFETY REQUIREMENTS

Title		Effective Date	
MEDICAL PLANNING		No. 12.4	Page No. 1 of 1

Statement of Requirement

Applicable Phase: A, B, C, D

Medical personnel shall participate in all program/mission planning, and preliminary design activities.

Background-Rationale

The primary consideration in manned spaceflight is that the men will survive in order to perform useful activities in space. Only medical personnel are qualified to determine the requirements for man's survival in space, and to determine what is necessary to insure that man performs most efficiently in the performance of assigned tasks in the space environment.

Approval

Title	Effective Date	No.	Page No.
BIOLOGICAL EFFECTS OF THE SPACE ENVIRONMENT		12.5	1 of 1

Statement of Requirement

Applicable Phase
A, B, C, D

Before long-term space missions are attempted, possible long-term biological effects of exposure to space flight conditions must be identified and if these effects are serious enough to affect the health of the crew, action must be taken to counteract these effects. If this is not feasible, close medical monitoring over and above routine monitoring of the biological functions that could be affected is required during the mission. This monitoring shall occur at intervals of time such that any degradation of biological functions will be detected and arrested before the health of the crew is seriously affected.

Background-Rationale

Although man's knowledge of the biological effects of exposure to space flight conditions (weightlessness, confinement, etc.) is increasing, very little data on possible long term exposure to space flight conditions is available at the present time. Several aspects of the biological effects of the space environment are receiving very little attention. These areas of study include, long term effects of cosmic radiation, and long term effects of low magnetic fields or high magnetic fields if a magnetic space radiation shield is to be used. The absence of a magnetic field could become a serious problem on long term interplanetary or lunar space missions.

Approval

APPENDIX A

GLOSSARY OF TERMS

ABORT	Premature termination of a mission because of existing or imminent degradation of mission success accompanied by the decision to make safe return of the crew the primary objective.
ACCEPTANCE	The act of a representative of the Government by which the Government assents to ownership of existing and identified articles, or approves specific services rendered as partial or complete performance of the contract.
ACCEPTANCE TESTS	Tests performed to verify that the end-item hardware conforms to all applicable specifications.
ANOMALY	Any irregularity recognized in flight, test, or development operations.
APPORTIONMENT	See Reliability Apportionment
ARTICLE	A unit of hardware or any portion thereof required by the contract.
ASSEMBLY	A number of parts or subassemblies or any combination thereof joined together to perform a specific function.
CHARACTERISTIC	Any dimensional, visual, functional, mechanical, electrical, chemical, physical, or material feature or property; and any process-control element which describes and establishes the design, fabrication, and operating requirements of an article.
COMPONENT	A combination of parts, subassemblies, or assemblies, usually self-contained, which performs a distinctive function in the operation of the overall equipment. A "black box." Under certain circumstances a part may be considered a component when its failure constitutes a critical failure.
CONFIGURATION	The technical and physical description required to fabricate, test, accept, operate, maintain and logistically support systems or equipment.
CREW SAFETY	Safe return of all crew members whether or not the mission is completed.
CRITICAL FAILURE	Any failure which results in loss of life and/or which results in mission loss or abort.

CRITICAL COMPONENT — A component, the failure of which will adversely affect crew safety and/or will result in mission loss or abort.

DESIGN SPECIFICATION — A document prescribing criteria to be satisfied in designing a particular component, subsystem, or system (or part). Typical criteria include performance requirements under specified environments, interface requirements, size, weight, ruggedness, safety margins, derating factors, and apportioned reliability goal (with definition of failure).

END ITEM — A space system or any of its principal system or subsystem elements, e.g., launch vehicle, spacecraft, ground support system, propulsion engine, or guidance system. Also, articles covered by major subcontracts or articles which will be delivered direct to a Government installation or provided as GFP to a contractor.

EQUIPMENT — One or more assemblies, or a combination of items, capable of performing a complete function.

FAILURE — The proven inability of a system, subsystem, component or part to perform its required function during test, operation or end use.

FAILURE ANALYSIS — The study of a specific failure, which has occurred, in order to determine the circumstances that caused the failure and to arrive at a course of corrective action that will prevent its recurrence.

FAILURE MODE, EFFECT AND CRITICALITY ANALYSIS

- **FAILURE MODE ANALYSIS** — The study of a space system and working interrelationships of the parts thereof under various anticipated conditions of operation (normal and abnormal) to determine probable location and mechanism, by which failures will occur.
- **FAILURE EFFECT ANALYSIS** — Study of the potential failures which might occur in any part of a space system to determine the probable effect of each on all other parts of the system and on probable mission success.
- **FAILURE CRITICALITY ANALYSIS** — Study of the potential failures which might occur in any part of a space system in relation to other parts of the system to determine the severity of effect of each failure in terms of a probable resultant safety hazard, unacceptable degradation of performance, or loss of mission of a space system.

HARDWARE	The physical objects, as distinguished from their capability or function.
HAZARD	An act or condition which could result in injury or loss to personnel, equipment or property.
HAZARD (OPERATIONAL)	Specific operation requiring activation of safety precautions.
HUMAN ERROR	A human action that is outside previously established criteria of acceptability, or is based on an incorrect interpretation of a set of factors.
INSPECTION	The examination, including testing, of contract work, articles, and services to determine conformance to contract requirements.
INTEGRATED SYSTEMS TEST	Tests performed to verify that all systems will meet performance requirements as an integrated system and are physically, functionally and operationally compatible with mating hardware systems and Ground Support Systems.
LIMITED LIFE ARTICLES	All items that have a useful life dependent on a predetermined number of operating hours or cycles.
MAINTAINABILITY	The quality of the combined features of equipment design and installation that facilitates the accomplishment of inspection, test, checkout, servicing, repair, and overhaul with a minimum of time, skill and resources in the planned maintenance environments.
MODEL	An analytic or physical analogue or representation of a system which describes the system characteristics and/or processes in significant details under the influence of the permissible range of variation of all the independent variables.
NASA INSTALLATION	A major organizational unit of the NASA; includes Headquarters and field installations. Field installations are assigned specific missions in the NASA space program.
PART	One peice, or two or more pieces joined together, which are not normally subject to disassembly without destruction of designed use.

QUALIFICATION — Determination by a series of tests and/or examinations of documents and processes that a part, component, subsystem, or system is capable of meeting performance requirements prescribed in the purchase specification or other documents specifying what constitutes adequate performance capability for the item in question.

QUALIFICATION TEST — A test or series of tests conducted to determine whether a part, component, subsystem, or system meets qualification requirements.

QUALITY CONTROL — A management function to control the quality of articles to conform to quality standards.

REDUNDANCY (of Design) — The use of more than one means of accomplishing a given task or function where all must fail before there is an over-all failure of the system.

RELIABILITY — The probability that a system, subsystem, component, or part will perform its required functions under defined conditions at a designated time and for a specified operating period.

RELIABILITY APPORTIONMENT — The assignment (by derivation from the contractual reliability requirement) of reliability goals to systems, subsystems, and components within a space system which will result in meeting the over-all contractual reliability requirement for the space system if each of these goals is attained.

RELIABILITY ASSESSMENT — An analytical determination of numerical reliability of a system or portion thereof. Such assessments usually employ mathematical modeling, use of directly applicable results of tests on system hardware, and some use of estimated reliability figures.

RELIABILITY DEMONSTRATION — Statistically designed testing, with specified confidence level, to demonstrate that an item meets the established reliability requirement.

RELIABILITY PREDICTION — An analytical estimation of numerical reliability of a system or portion thereof similar to a reliability assessment, except that the prediction is normally made in the earlier design stages where very little directly applicable test data is available.

SAFETY — Freedom from those conditions which can cause injury or death to personnel, damage to or loss of equipment, or property.

SINGLE FAILURE POINT	A single item of hardware which, if it fails, would lead directly to loss of life or loss of mission.
SPACE SYSTEM	A system of equipment consisting of launch vehicle(s), spacecraft, ground support equipment, and test hardware, used in ground testing launching, operating and maintaining space vehicles or spacecraft.
SPACE VEHICLE	A launch vehicle and its associated spacecraft.
SYSTEM	One of the principle functioning entities comprising the project hardware and related operational services within a project or flight mission. Ordinarily, a system is the first major subdivision of project work. Similarly, a subsystem is a major functioning entity within a system. (A system may also be an organized and disciplined approach to accomplish a task, e.g., a failure reporting system.)
SYSTEMS INTEGRATION	The management process by which the systems of a project (for example, the launch vehicle, the spacecraft, and its supporting ground equipment and operational procedures) are made compatible, in order to achieve the purpose of the project or the given flight mission.
SYSTEM SAFETY	The optimum degree of safety within the constraints of operational effectiveness, time, and cost attained through specific application of system safety engineering throughout all phases of system development and utilization.
SYSTEM SAFETY ENGINEERING	An element of systems management throughout the program life cycle involving the application of scientific, engineering, and management principles for the timely identification of those actions necessary to prevent or control hazards within the system.
VERIFICATION	The process whereby any system element (e.g., flight hardware, ground support equipment, ground operational support system) demonstrates its capability to perform specified requirements. The process may include flight tests, ground tests, special studies, and qualification testing.
WARNING DEVICES	Sensors that monitor or detect conditions and provide visible and/or audible alerting signals as desired for selected events.